Boonton *ELECTRONICS* Corporation

MORRIS PLAINS, NEW JERSEY

10125

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INSTRUCTION BOOK

MODEL 91-C

RF VOLTMETER

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Boonton *ELECTRONICS* Corporation

738 SPEEDWELL AVENUE, MORRIS PLAINS, NEW JERSEY, U. S. A.

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SECTION I

MODEL 91-C

SPECIFICATIONS

1-1 Measurement Range:	1 millivolt to 3 volts
1-2 Full Scale Ranges:	.003, .01, .03, .1,.3,1,3 volts
1-3 Frequency Range:	50 KC to 600 MC
1-4 Accuracy:	5% of full scale to 200 MC 10% of full scale above 200 MC
1-5 Input Impedance :	Hi-Z Probe See curve for shunt resistance data on high impedance probe. Shunt capacitance varies inversely with input voltage from 2 to 5 μμf. 52 Ohm Adapter Max. VSWR 1.2 up to 600 MC
1-6 Tube Complement:	1 each: 12AX7, 12AT7, 6AU6, 0A2 and 6X4.
1-7 Power Requirements:	105-125 volts, 55-65 cycles, 30 watts.

SECTION II

GENERAL DESCRIPTION

The Model 91-C RF Voltmeter is designed to measure radio frequency voltage levels from 1 millivolt to 3 volts over a frequency range of 50 kilocycles to 600 megacycles. Seven ranges, from .003 to 3 volts full scale are provided, plus a continuous calibration in decibels covering a range of 70 db.

A general purpose high impedance probe and a 52 ohm adapter are supplied with each instrument. The adapter provides a 52 ohm termination with a BNC coaxial connector, and produces a low VSWR up to at least 600 megacycles. A full wave crystal diode detecting circuit is used. This produces close to RMS response for all voltage levels below approximately .1 volt, changing to peak reading (calibrated in RMS) at higher levels. The full wave detector helps to minimize errors due to non-sinusoidal waveforms.

The high impedance probe has a shunt capacitance of approximately 2.5μμf at levels of 1 volt or higher, increasing to double that value at levels of .1 volt or less. The shunt resistance component is also a variable factor, depending on the voltage and frequency. (See Figure 1).

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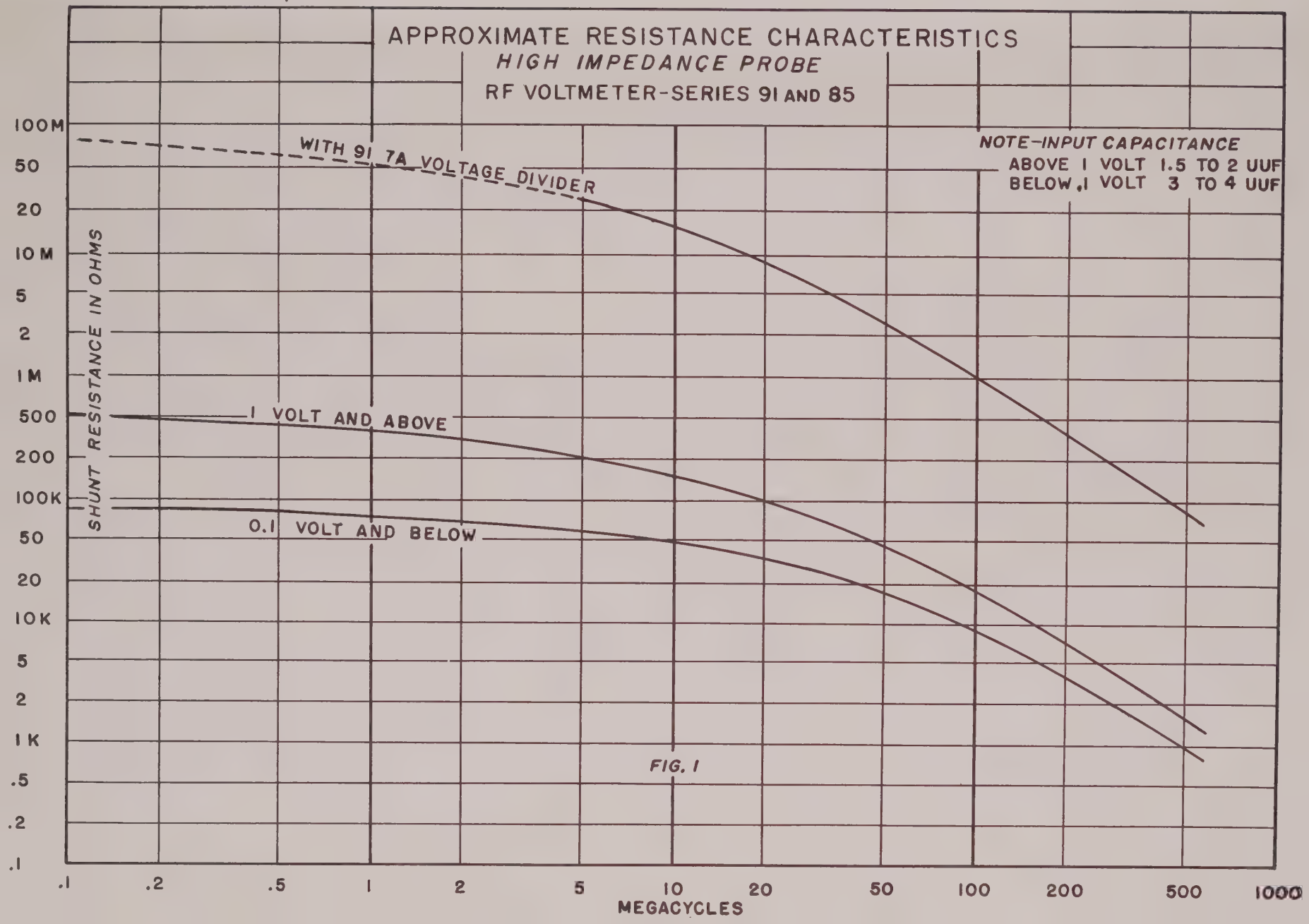


FIG. 1

SECTION III

OPERATING PROCEDURE

3-1 General

3-2 This section describes in detail the operating procedure for the Model 91 RF Voltmeter. All information required for safe and proper operation of the instrument is included. Be sure to read this section before placing the instrument into operation.

3-3 Initial Turn-On Procedure and Tests

3-4 Tests. To perform the initial tests proceed as follows:

a. After unpacking the unit, and before plugging it into an a-c outlet for the first time, turn the instrument back and forth several times to make sure the tubes have not fallen from their sockets due to rough handling.

b. Observe the meter pointer to see that it moves freely and rests at zero when the instrument is steady.

c. If the pointer rests to the right or left of zero, set it at zero with the zero set screw.

CAUTION

Before plugging the instrument into the convenience outlet, make sure the power supply is 105-125 volts ac, 55-65 cycles, unless otherwise specified on nameplate.

3-5 Turn-On Procedure. To perform the initial turn-on procedure proceed as follows:

a. Plug the instrument into the power source.

b. Set the toggle switch to ON (up), and allow a warm-up period of approximately one minute.

c. Connect input cable assembly to the instrument at jack marked PROBE.

d. Connect HI-Z PROBE to other end of cable. Check serial number of probe and see that it is the same as that of the voltmeter.

e. Check meter deflection on all ranges with probe tip shorted to probe case ground. Normal meter deflections are as follows:

RANGE	DEFLECTION
.003	less than $\frac{1}{8}$ inch
.01, .03, .1, .3, 1	Zero
3	Suppressed

3-6 Measurement Procedure

a. Set RANGE-FULL SCALE control to appropriate setting (or higher) for voltage to be measured.

b. Connect probe case to ground point of voltage source under test. This connection must be as short and direct as possible to minimize errors arising from circulating RF currents in the ground return impedance.

c. Connect probe tip to high point of voltage source under test. This connection must also be as short as possible to minimize resonance rise effects at frequencies above 100 megacycles.

d. Read RF voltage on appropriate meter scale corresponding to setting of RANGE-FULL SCALE control.

e. To obtain relative level readings in decibels add the DB (red scale) meter reading to the DB (red) setting of the RANGE-FULL SCALE control. Although individual DB readings have no significance as measured on the 91 type RF Voltmeter the difference between two DB readings represents the actual change in level on a decibel basis. When used with a good signal generator the DB scale greatly facilitates the measurement of relative attenuation and bendpass characteristics of networks.

f. As it is frequently desired to measure RF voltages in coaxial systems the Model 91 is provided with a 52 ohm coaxial adapter having a low VSWRup to 600 MC. In order to properly connect the adapter, first loosen the necessary screws on the side of the HI-Z Probe, then slip the adapter

over the end of the Hi-Z Probe and press firmly to insure contacting the center pin. Tighten screws to hold adapter in place.

3-7 Operating Precautions

3-8 Maximum Input Voltages

RF voltages exceeding 10 volts must not be applied to the probe or permanent damage to the crystal diodes may result. The 52 ohm adapter should not be subjected to continuous overloads exceeding 3.5 volts to avoid excessive heating of terminating resistor.

Maximum DC voltage for Hi-Z probe is 300 volts.
Maximum DC voltage for 52 ohm adapter is 3.5 volts.

Note: Do not apply maximum DC voltage simultaneously with maximum RF voltage when using 52 ohm adapter.

3-9 Temperature Effects

The normal ambient temperature range for specified accuracy is 65° to 90° F. Appreciable inaccuracies can be expected while the probe is exposed to temperatures above or below this range. No permanent change in probe characteristics will result from the high or low temperature exposure.

Inaccuracies due to temperature effects may occur after soldering to the probe tip or from heat sources such as resistors or tubes.

When making low level measurements in the order of 2 millivolts or less, it is important to make sure that the probe has attained a uniform temperature throughout. A temperature difference between the inside and outside of the probe can generate a small thermal voltage that may add to or subtract from the DC voltage generated by the diodes.

3-10 Hum, Noise and Spurious Pick-up

When measuring low level RF voltages, precautions should always be taken to avoid the possibility of erroneous readings resulting from hum, noise, or stray RF pick-up. Although all low frequency hum and noise is attenuated at the input by 60 DB, it is still possible for high level unwanted signals to get through and cause errors. The best test for this condition is

to reduce the test signal to zero level and note whether the voltmeter continues to read some spurious signal level. In some cases it may be necessary to provide extra shielding around the probe connections to reduce stray field pick-up. Typical sources of spurious radiation are induction or di - electric heating units, diathermy machines, local radio trans- mitters, grid dip meters and amplifiers with parasitic oscillatons.

SECTION IV

THEORY OF OPERATION

An understanding of the operating features of the Model 91 Sensitive RF Voltmeter may be obtained by a study of the block diagram (Fig. 2) in conjunction with the following description.

The radio frequency voltage to be measured is rectified in the RF Probe by means of a full wave germanium diode rectifier circuit. The resulting DC potential is then attenuated as required before conversion to 60 cycle AC by the chopper. This AC signal is then amplified in a narrow band feed-back stabilized amplifier prior to its re-conversion to DC for use in actuating the meter.

The germanium diodes used in the RF Probe have been carefully selected for frequency response, temperature coefficient, capacitance and conductance. As the selected diodes do not all exhibit the same rectification efficiency characteristics, it becomes necessary to adjust each meter range to match individual probe diodes. The range adjustments consist of individual non-linear circuits shunting the output meter circuitry. As the RANGE switch is set to the required test voltage position the appropriate non-linear adjusting circuit is automatically shunted across the output. It is also important to understand that the non-linear output circuitry is designed to compensate for the non-linear characteristics of the probe diodes when operating at levels below .3 volts.

SECTION V
MAINTENANCE

5-1 Periodic Checking

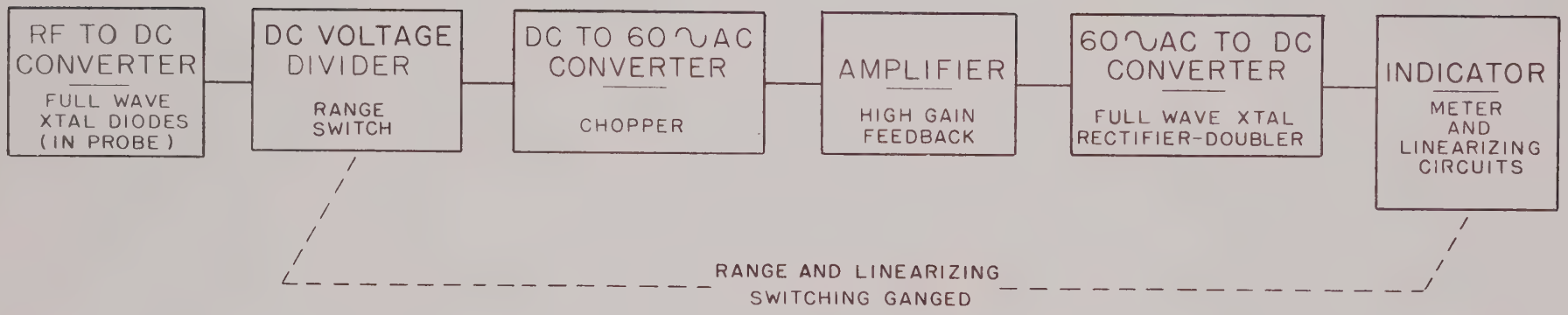
The Model 91 Voltmeter is designed to give long periods of service without maintenance when operated in accordance with these instructions. It is recommended, however, that the instrument be checked occasionally using reliable standards to insure against errors resulting from deterioration of tubes or chopper. To make these checks, it is necessary to have a signal source in the 200 to 500 KC region with less than 2% distortion at levels up to 3 volts across 50 ohm. A precision electronic voltmeter of the averaging response type, such as the Ballantine Model 310A or 314 Hewlett Packard Model 400D or 400H, may be used to monitor the signal source for this purpose. To insure its accuracy, the monitoring meter should be checked at some low frequency (50-100 cycles) of good waveform against a dynamometer type AC meter of at least 1% accuracy.

5-2 Calibration Precautions

When attempting to check the voltage calibration accuracy on an instrument having the sensitivity and bandwidth of the Model 91, it is essential to take precautions to avoid errors resulting from stray pick-up voltages. (See para. 3-10). A well shielded signal source must be used in conjunction with coaxial connections to both the Model 91 and the standard reference meter. Even with a well shielded generator and associated connections, it is sometimes possbile for the reference meter to pick up stray RF signals and feed them into the probe. Check for this condition by disconnecting standard meter and noting change in level.

5-3 Calibration Check Procedure

With suitable calibrating equipment (para. 5-1) and taking necessary precautions (para.5-2), we can now check the Model 91 for calibration accuracy. Each range should be checked at a voltage representing 90% of full scale value.



BLOCK DIAGRAM

TYPE 91, RF VOLTMETER

FIGURE 2

If these check points agree within ± 2% of the standard, it is recommended that no adjustment be made. If the check points deviate by more than ± 5% from the standard, it is recomemnded that a trouble shooting procedure be followed as outlined in para. 5-4. If the check points fall between 2% and 5% of the standard, the calibration adjustment procedure as outlined in para. 5-5 should be followed.

5-4 Trouble Shooting Procedure

a. Case Removal

The instrument may be removed from its case after first removing the two screws located at the back of the case (near the bottom) and the four screws located on the sides of the case near the front.

The power supply may be removed from the case after first removing the four screws located on the sides of the case near the rear.

b. Tube Replacement

Any tube (except V1-12AX7) found to be defective or weak, may be replaced without major effect on the calibration or general performance. If the 12AX7 tube (V1) should become weak or noisy, it should be replaced with one having exceptionally low noise and microphonism. A Satisfactory replacement tube may be obtained either from the Boonton ELECTRONICS Corporation or by selection from a few tubes purchased from the manufacturer of the original 12AX7 in the Model 91.

After replacing defective tubes, re-check calibration as outlined in para. 5-3 and adjust if necessary as described in para 5-5.

c. Chopper Replacement

If a satisfactory operation is not obtained by replacing tubes, a replacement chopper of the same make and designation should be tried. If the new chopper does not clear the difficulty, place the original chopper back in socket. If new chopper does clear the difficulty, the calibration accuracy must be re-checked and adjusted, if necessary.

d. Voltage and Resistance Tests

After determining that the trouble cannot be cured by replacement of tubes or chopper, as described previously, it is advisable to make a systematic check of AC voltage, DC voltage and resistance at each socket pin. Table I shows the nominal AC and DC voltages to ground from each socket pin number. Table II shows the nominal resistance values expected for each point. Large or erratic deviations from the listed values of voltage or resistance will serve as a valuable clue in tracking down a faulty component. Once the trouble has been found and corrected, the calibration must be re-checked and re-adjusted as outlined in para. 5-3 and para. 5-5.

5-5 Calibration Adjustment Procedure

Before making any calibration adjustments, it is essential to provide the necessary reference standards as described in para. 5-1 and take all precautions as outlined in para. 5-2. The calibration adjustment procedure shall then be made as outlined in Table III.

TABLE I

VOLTAGE MEASUREMENTS

Conditions:

117V 60 ~ line input.

VTVM used for all measurements.

All measurements to chassis unless otherwise noted.

Input .01V at any frequency between 100KC and 1 MC.

Use Ballantine Model 314 VTVM for all AC voltage measurements.

Pin #		1	2	3	4	5	6	7	8	9	10	11
Tube												
V1 (12AX7)	DC	78	0	.83	53	53	95	0	.9	46	-	-
	AC	2.5 mv	1.5 mv				.14V	2.5 mv			-	-
V2 (6AU6)	DC	.82	2	59	53	30	45	2	-	-	-	-
	AC	.076V				.86V						
V3 (12 AT7)	DC	135		2.3	53	53	250	66	74	53	-	-
	AC	27V	.76V					27V	25V		-	-
V4 (6X4)	DC			53	53			300				
	AC	235					235					
V5 (0A2)	DC	150				150						
	AC											
11 Pin socket	DC	53	53			53		150	250	0	46	59
	AC											
Chopper Socket	DC											
	AC			1.5 mv								
Pin 10 to Pin 11 of 11 Pin Socket				DC 12.6V AC .36V								
Pin 10 to Pin 5 of 11 Pin Socket				DC 6.3V AC .015V								

TABLE II

RESISTANCE MEASUREMENTS

Conditions:

Power turned off.

Tubes in sockets, chassis interconnected (11 Pin), all measurements to chassis.

Pin #	1	2	3	4	5	6	7	8	9	10	11
Tube											
V1 (12AX7)	1M	6.8M	11K	16K	16K	500K	2.2M	6.8K	16K	-	-
V2 (6AU6)	2.5M	3.8K	16K	16K	500K	1M	3.8K	-	-	-	-
V3 (12AT7)	135K	1M	2.2K	18K	18K	55K	500K	18.5K	18K	-	-
V4 (6X4)	300	∞	19K	19K	∞	300	50K	-	-	-	-
V5 (0A2)	50K	0	∞	0	50K	∞	0	-	-	-	-
11 Pin Conn.	.19K	19K	∞	∞	17K	∞	45K	60K	0	16K	16K

TABLE III

CALIBRATION ADJUSTMENT PROCEDURE

Step	Reference Std. Voltage	Voltage Range Setting Model 91	Adjust to read	Adjusting Screw No.	Notes
1	.900	1	.90	1	Adjusting screws numbered from front to rear on right side of cabinet. No. 1 is gain adjustment.
2	1.00	3	1.00	2	Meter bias adjustment, affects down scale readings most.
3	.280	.3	.280	3	Slope adjustment, affects full scale readings more than down-scale readings.
4	.0300	.1	.0300	4	Gain adjustment, affects all ranges from .1 volt to .003 volt.
5	.0900	.1	.0900	5	Slope adjustment, affects upper readings most.
6	.0280	.03	.0280	6	Slope adjustment, afftecs upper readings most.
7	.00900	.01	.00900	7*	Slope adjustment, affects upper readings most.
8	.00280	.003	.00280	8*	Slope adjustment, affects upper readings most.

* These adjusting screws are numbered from back to front on left side of cabinet.

WARRANTY

Boonton ELECTRONICS Corporation guarantees to the original purchaser that each instrument it manufactures be free from defects in material and workmanship for a period of one year after date of initial shipment. Our liability is limited to repairing or replacing any defective part with the exception of vacuum tubes, panel lamps, fuses, choppers and batteries. The warranty lapses if, upon our examination, we judge that the instrument has been abused in any way.

PROCEDURE TO FOLLOW WHEN INSTRUMENT IS DEFECTIVE

1. Call our plant or our representative nearest you. A simple solution may result from discussion of the problem with our trained personnel.
2. If the fault is not readily eliminated, prepare the instrument for return to us. Pack carefully in a sturdy container using several inches of shock abosrbing material on all six sides of the instrument. Include all probes, cables, or accessory units. On all paper work pertaining to the returned instrument, note the model and serial number and state briefly the details of the fault. Ship to us transportation charges prepaid.
3. If the instrument is within the warranty, we will repair and return to you transportation charges prepaid. If the instrument is beyond the one year warranty period, we will repair and return it unless approval on a cost estimate is requested. If the instrument is within the one year warranty period, but our examination reveals abuse, we will await approval of our cost estimate before proceeding with repairs.

PARTS LIST

FOR 91-C AND 91-CA

C1	Capacitor	.001 Mucon SO 3709
C2	Capacitor	.001 Allen Bradley SA-102X
C3	Capacitor	.001 Allen Bradley SA-102X
C4	Capacitor	.1 at 200V Goodall 620M10402
C5	Capacitor	.1 at 200V Goodall 620M10402
C6	Capacitor	.1 at 200V Goodall 620M10402
C7	Capacitor	.1 at 200V Goodall 620M10402
C8	Capacitor	.0033 at 200V Goodall 620M33202
C9	Capacitor	.01 at 300V Goodall 620M10303
C10	Capacitor, Electrolytic	20µf. 475V P/O Mallory FP 379.1
C11	Capacitor	.005 at 200V Goodall 620M50202
C12	Capacitor,Electrolytic	50µf. 6V Cornell Dublier BBR-50-6
C13	Capacitor	.1 at 200V Goodall 620M10402
C14	Capacitor, Mica	.001 Sangamo K1210B20
C15	Capacitor, Mica	.001 Sangamo K1210B20
C16	Capacitor, Mica	.001 Sangamo K1210B20
C17	Capacitor	.005 at 200V Goodall 620M50202
C18	Capacitor	.1 at 200V Goodall 620M10402
C19	Capacitor,Electrolytic	20µf. 25V P/O Mallory FP-379.1
C20	Capacitor	.01 at 300V Goodall 620M10303
C21	Capacitor	1.0 µf at 200V Aerovox P-82
C22	Capacitor	1.0 µf at 200V Aerovox P-82
C23	Capacitor,Electrolytic	20µf. 475V P/O Mallory FP 376.5
C24	Capacitor,Electrolytic	20µf. 475V P/O Mallory FP 376.5
C25	Capacitor,Electrolytic	20µf. 475V P/O Mallory FP 376.5

C26	Capacitor, Electrolytic	1000µf. 15V Mallory WP-200
C27	Capacitor,Electrolytic	1000µf. 15V Mallory WP-200
C28	Capacitor,Electrolytic	50µf. 6V Cornell-Dublier BBR-50-6
C29	Capacitor,Electrolytic	50µf. 6V Cornell-Dublier BBR-50-6
C30	Capacitor,Electrolytic	50µf. 50V P/O Mallory FP 379.1
C31	Capacitor,Electrolytic (Used in 91-CA only)	50µf. 25V Industrial Cond.52RMV50
CH1	Chopper	Stevens Arnold A-19 (91-C) Bristol C1417-8 (91-CA above Serial No. 639)
D1	Diode, Selected	
D2	Diode, Selected	
D3	Diode, Silicon	Transitron 1N600
D4	Diode, Silicon	Transitron 1N600
D5	Diode, Silicon	Transitron SG22
F1	Fuse	1 AMP
I1	Lamp	#47
I2	Lamp	#47
I3	Lamp	#47
J1	Receptacle	Amphenol UG-290/U
J2	Receptacle	Amphenol 80-911
J3	Receptacle	Amphenol 80-PC-2F
J4	Socket	Amphenol 77-MIP-11
L1	Choke, Filter	Stancor C1707
M1	Meter(Special 200µa)	BEC 554,112

P1	Plug (Input Cable)	Amphenol 80-MC-2M
P2	Plug (Input Cable)	Amphenol 80-MC-2M
P3	Plug (Amplifier)	Amphenol 86-PM11-11

All deposited carbon resistors are ± 1% 1/2W unless otherwise noted.

All composition resistors are ± 5% 1/2W unless otherwise noted.

R1	Resistor, Deposited Carbon	52Ω ± 1% 1/4W
R2	Resistor, Composition	10 K Ω
R3	Resistor, "	10 K Ω
R4	Resistor, "	330 K Ω
R5	Resistor, "	330 K Ω
R6	Resistor, Deposited Carbon	5 Meg.
R7	Resistor " "	5 Meg.
R8	Resistor, " "	576 K Ω
R9	Resistor, " "	576 K Ω
R10	Resistor, " "	47.5 K Ω
R11	Resistor, " "	47.5 K Ω
R12	Resistor, " "	6.81 K Ω
R13	Resistor, " "	6.81 K Ω
R14	Resistor, " "	1.39 K Ω
R15	Resistor, " "	1.39 K Ω
R16	Resistor, " "	675 Ω
R17	Resistor, " "	675 Ω
R18	Resistor, Composition	2.22 K Ω
R19	Not used	
R20	Resistor, Composition	6.8 Meg.
R21	Resistor, "	1 Meg

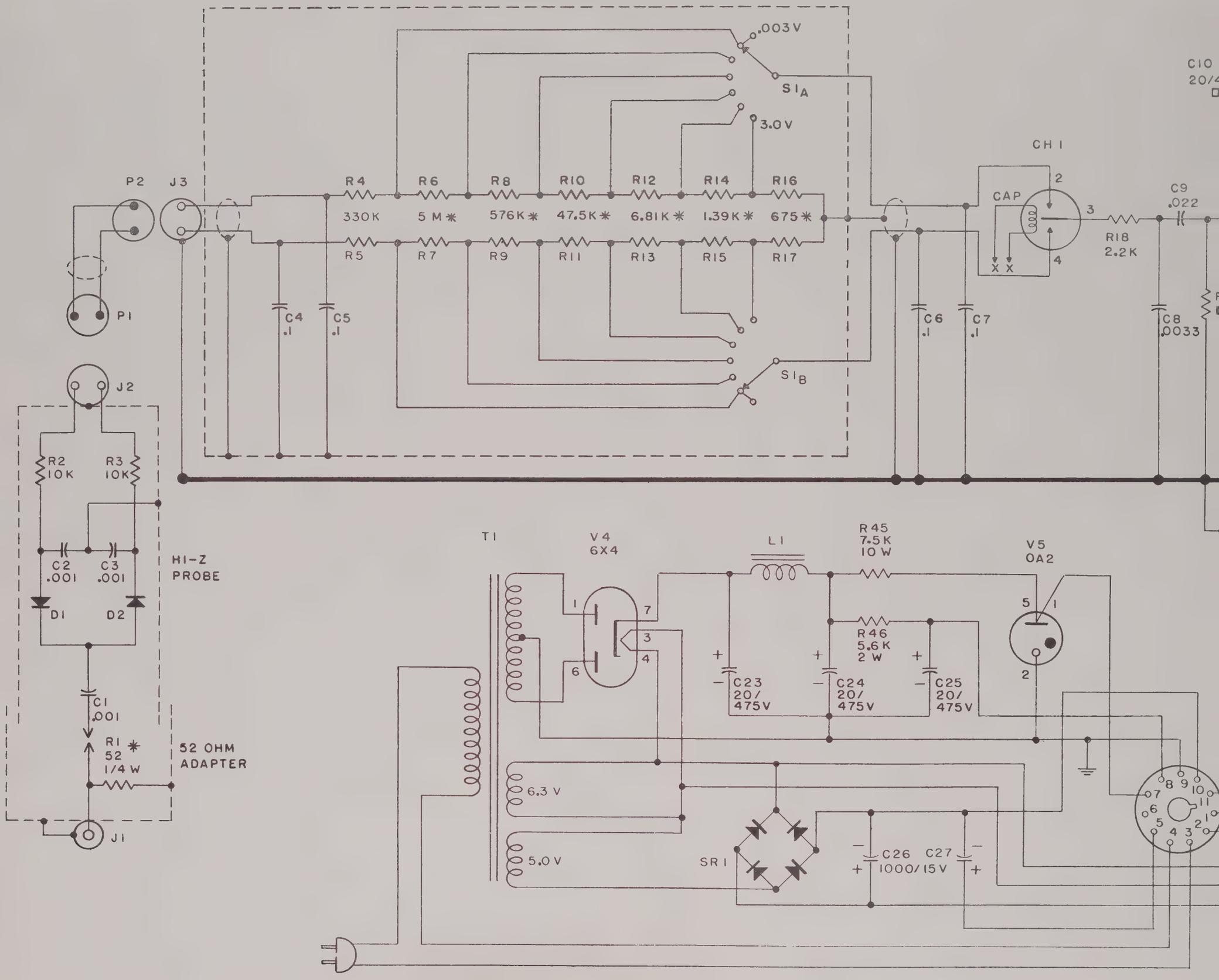
R22	Resistor, Deposited Carbon	845 Ω
R23	Resistor, " "	10 K Ω
R24	Resistor, " "	1 Meg
R25	Resistor, Composition	470 K Ω
R26	Resistor, "	6.8 K Ω
R27	Resistor, "	2.2 Meg
R28	Resistor, "	470 K Ω
R29	Resistor, "	470 K Ω
R30	Resistor, "	470 K Ω
R31	Resistor, "	470 K Ω
R32	Resistor, Deposited Carbon	2 K Ω
R33,	Resistor, Variable Comp.	2K ± 20%
R34,	Resistor, " "	2K ± 20%
R35	Resistor, Deposited Carbon	845 Ω
R36	Resistor, Composition	1 Meg.
R37	Resistor, Deposited Carbon	1 Meg.
R38	Resistor, Composition	100 K Ω
R39	Resistor, "	2.2 K Ω
R40	Resistor, "	470 Ω
R41	Resistor, "	18 K Ω
R42	Resistor, "	470 K Ω
R43	Resistor, Deposited Carbon	73.2 K Ω
R44	Resistor, " "	5.9 K Ω
R45	Resistor, Composition	7.5 K Ω ± 10% 10W
R46	Resistor, "	5.6 K Ω ± 5% 2W
R47	Resistor, "	220 Ω
R48	Resistor, "	18 K Ω

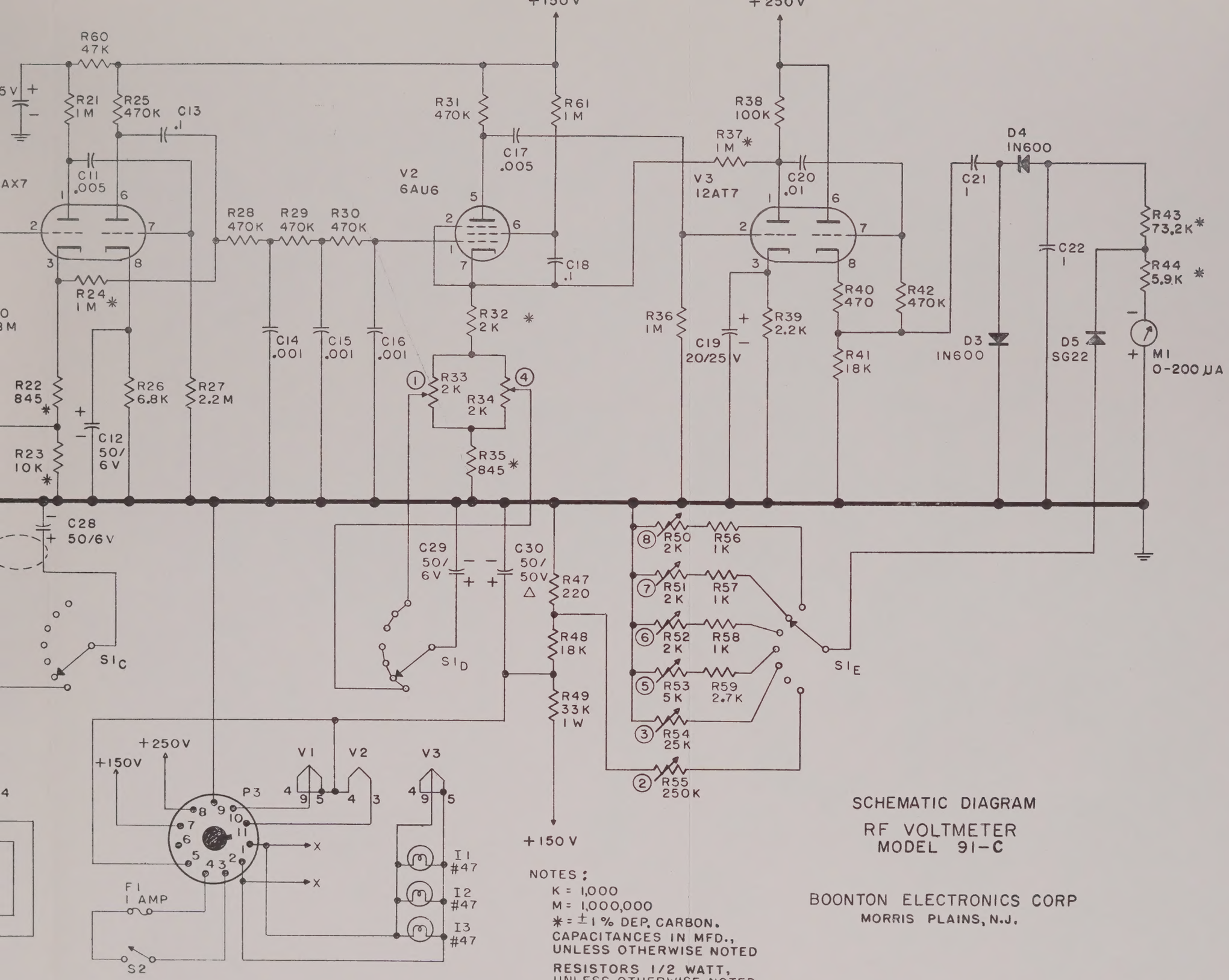
R49	Resistor, Composition	33KΩ ± 5% 1 W
R50	Resistor, Variable, Comp.	2KΩ ± 20%
R51	Resistor, " "	2KΩ ± 20%
R52	Resistor, " "	2KΩ ± 20%
R53	Resistor, " "	5KΩ ± 20%
R54	Resistor, " "	25KΩ ± 20%
R55	Resistor " "	250KΩ ± 20%
R56	Resistor, Composition	1KΩ
R57	Resistor "	1KΩ
R58	Resistor, "	1KΩ
R59	Resistor, "	2.7KΩ
R60,	Resistor, "	47KΩ
R61	Resistor, "	1 Meg.
R62	Resistor, Variable Comp.	100KΩ (Used in 91-CA only)
R63	Resistor, Composition	220KΩ ±5% " " " "
R64	Resistor, "	10Ω ± 5% " " " "
R65	Resistor, "	22 Meg. ± 10% " " "
R66	Resistor, "	22 Meg. ± 10% " " "
R67	Resistor, "	8.2 KΩ ± 10% " " "
R68	Resistor, "	8.2 KΩ ± 10% " " "
SR1	Rectifier, Selenium	Sarkas-Tarzian 304-B
S1	Switch, special	BEC 466,114 for 91-C BEC 466,113 for 91-CA
S2	Switch, Toggle, DPST	
T1	Transformer, Power (Special)	BEC 446,007

6. SHIPPING INSTRUCTIONS

6-1 If it becomes necessary to ship the instrument for any reason it is essential to make sure that the chopper is properly secured in its socket. It has been found necessary to tie a piece of twine or wire around the hold down clamps at the base of the chopper to prevent the weight of the chopper from spreading these clamps and its falling out during shipment. Very often the clamps are not re-tied when replacing the chopper in the field.

6-2 Wrap the instrument with heavy wrapping paper and seal the seams with gummed tape. Place in fibre-board carton large enough to permit 3 inches of soft packing material between instrument and sides of box.


.003V
S1A
3.0V
S1B
P2
J3
P1
J2
J1
R4
330K
R6
5 M*
R8
576K*
R10
47.5K*
R12
6.81K*
R14
1.39K*
R16
675*
R5
R7
R9
R11
R13
R15
R17
C4
.1
C5
.1
C6
.1
C7
.1
CH 1
CAP
X X
R18
2.2K
C9
.022
C8
.0033
C10
20/4
R2
10K
R3
10K
C2
.001
C3
.001
D1
D2
HI-Z
PROBE
C1
.001
R1 *
52
1/4 W
52 OHM
ADAPTER
T1
V4
6X4
L1
R45
7.5K
10 W
V5
0A2
R46
5.6K
2 W
C23
20/
475V
C24
20/
475V
C25
20/
475V
6.3 V
5.0 V
SR1
C26
1000/15V
C27



SCHEMATIC DIAGRAM

RF VOLTMETER
MODEL 91-C

BOONTON ELECTRONICS CORP
MORRIS PLAINS, N.J.

NOTES:

K = 1,000
M = 1,000,000
* = ±1% DEP. CARBON.
CAPACITANCES IN MFD., UNLESS OTHERWISE NOTED
RESISTORS 1/2 WATT, UNLESS OTHERWISE NOTED
◯ = CALIBRATION CONTROL

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